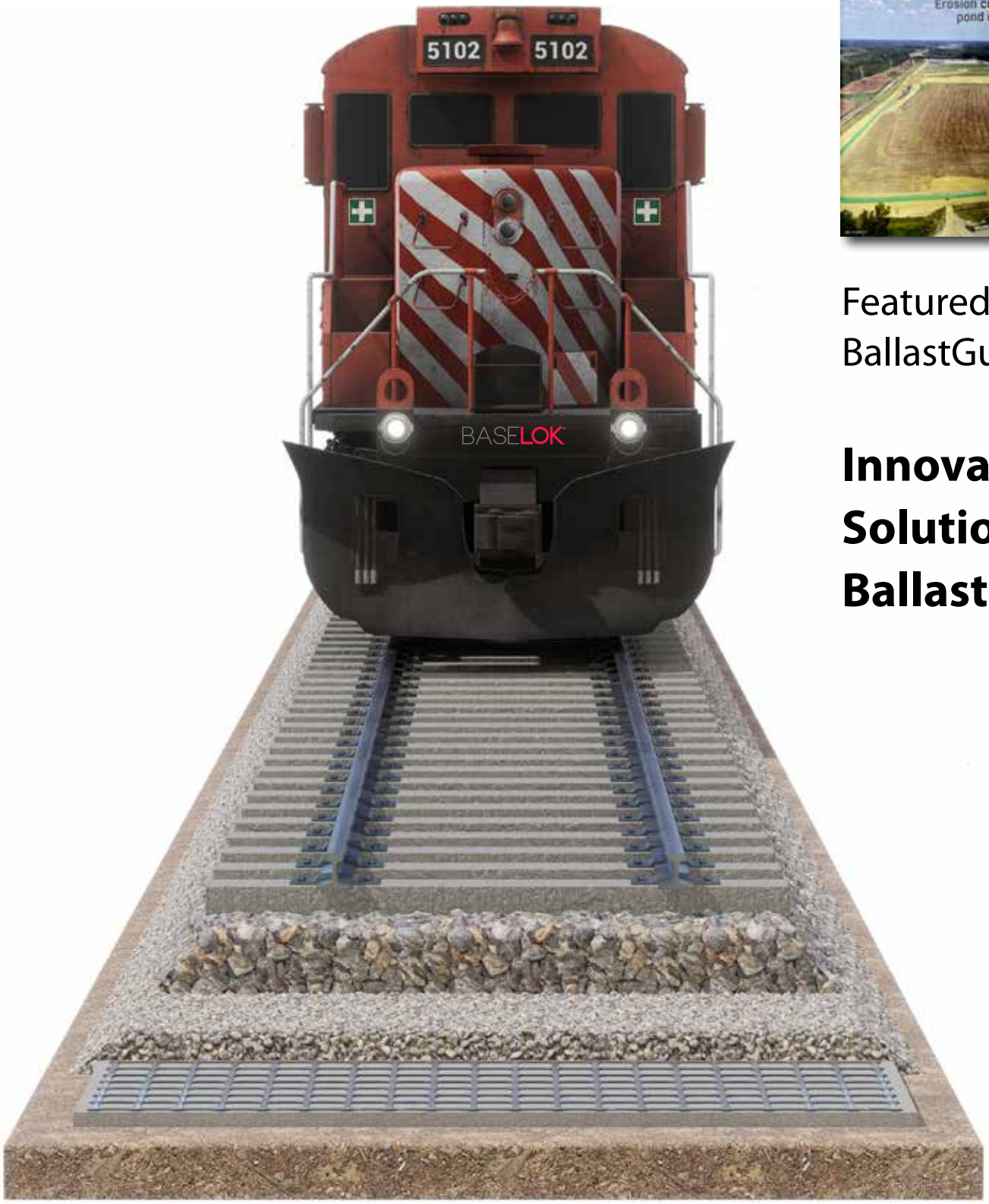
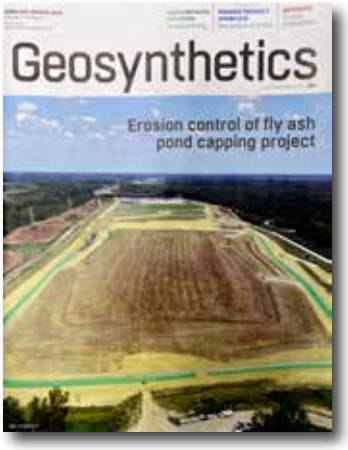
BALLAST GUARD™

Ballast Preservation System





Featured Article:
BallastGuard™

Innovative Solution for Ballast Fouling

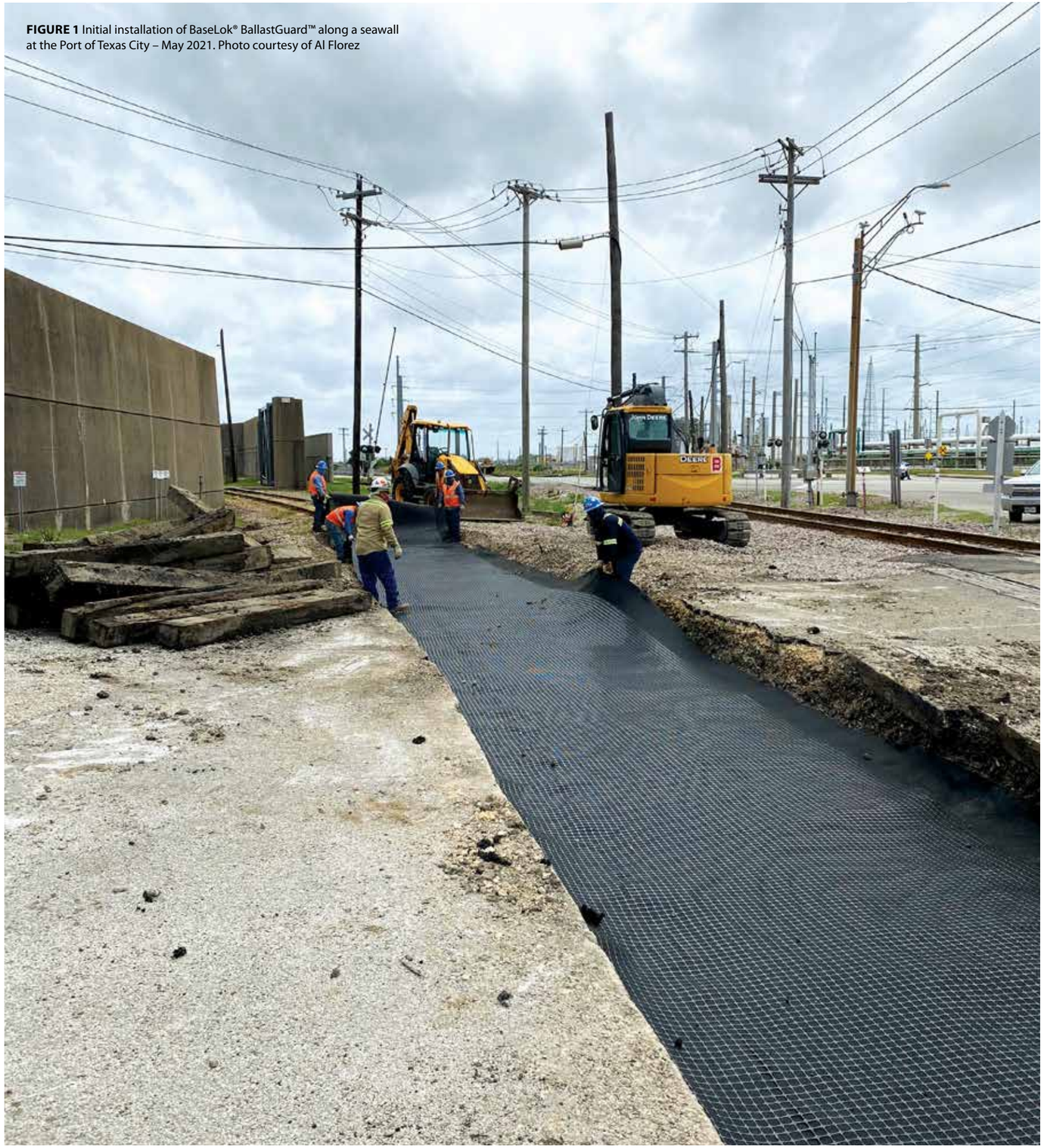


FIGURE 1 Initial installation of BaseLok® BallastGuard™ along a seawall at the Port of Texas City – May 2021. Photo courtesy of Al Florez

Innovative solution for ballast fouling

Geocomposite solution helps Port of Texas City, Texas City Terminal Railway Company.

By Keith C. Brooks, P.E.

Remy Steffer, director of engineering at the Port of Texas City, Texas City Terminal Railway Company, and Houston Belt and Terminal Railway, is very familiar with ballast fouling. Overseeing operations at a port facility south of Houston, Texas, Steffer has dealt with ballast fouling his entire career. The Port of Texas City is located approximately 45 miles south of downtown Houston on Galveston Bay. Its proximity to the bay creates an ever-present saturated subgrade, which significantly contributes to the ballast fouling phenomenon. According to Steffer, "Typically, in areas with a high water table such as ours, we would plan any fouled ballast remediation activities, per location, every three to five years. Texas City Terminal Railway Company spends on average $250,000 to $500,000 a year on fouled ballast remediation activities including undercutting, cribbing, and surfacing." Additionally, downtime on the railway is costly in terms of lost revenue, as less efficient routes are often required due to track maintenance outages (Brooks and Steffer 2022).

The Port of Texas City is privately owned by Union Pacific and Burlington Northern Santa Fe railroads. The port is operated by Texas City Terminal Railway Company and is the largest privately owned port in the country. Founded in 1893 as a harbor and rail operation, the Port of Texas City is now the eighth-largest port in the United States and the third-largest port in the state of Texas. More than 78 million waterborne tons of material move through the port annually (Moore Memorial Public Library, n.d.).

"Texas City Terminal Railway Company currently operates approximately 32 miles of tracks. Due to our proximity to the Gulf Coast and our previously mentioned high water table, fouled ballast locations occur throughout our entire track structure" (Brooks and Steffer 2022). In early 2021, Texas City Terminal Railway Company met with Industrial Fabrics, Inc. to discuss ongoing issues with railroad maintenance and ballast fouling. Headquartered in Baton Rouge, La., Industrial Fabrics, Inc. has a major geosynthetics manufacturing facility in south Houston

Keith C. Brooks, P.E. is director of engineering at Industrial Fabrics, Inc. in Houston, Texas. He has nearly two decades of experience designing with geosynthetics.

All figures courtesy of the author unless otherwise noted

FIGURE 2 Severe ballast fouling along a seawall at the Port of Texas City prior to installation of BaseLok® BallastGuard™ – May 2021. Photo courtesy of Al Florez

FIGURE 3 Severe ballast fouling on a site in Ohio – November 2022.

and manufactures multiple geosynthetic products utilized in heavy construction and rail applications. For this specific issue, Industrial Fabrics, Inc. identified its BaseLok line of products, which includes geocell, geogrids and laminated geogrids. Industrial Fabrics, Inc. was in the process of developing a new product to address ballast fouling with one of its key partners. Texas City Terminal Railway Company agreed to try this new product, which initiated installation of a test section in May 2021.

What exactly is ballast fouling?

Ballast fouling occurs when ballast becomes contaminated with fines and other deleterious material. Ballast is the aggregate directly beneath the railroad ties and rail. It is a rock material that is most often between 0.75 inches and 3 inches in diameter. This relative gradation allows for free drainage of water and notable structural integrity. "This range of particle-size is desirable for railroad track because it offers high strength and stiffness due to the high frictional resistance between ballast rock particles" (Bruzek et al. 2016). Interestingly, no federal standard or specification exists on ballast type or gradation. The Track Safety Standards (TSS) lists minimum track safety requirements. It is not considered a standard for design; rather, it is simply an inspection standard (Bruzek et al. 2016). The ballast safety standard found in §213.103 of the TSS (USDOT 2022) states:

Unless it is otherwise structurally supported, all track shall be supported by material which will—

- Transmit and distribute the load of the track and railroad rolling equipment to the subgrade;
- Restrain the track laterally, longitudinally, and vertically under dynamic loads imposed by railroad rolling equipment and thermal stress exerted by the rail;
- Provide adequate drainage for the track; and
- Maintain proper track crosslevel, surface, and alinement.

If fines or a high percentage of smaller particles are present, the integrity of the ballast and, therefore, these safety standards are compromised. This presence of contaminating small particles or fine material is generally referred to as ballast fouling.

Attempting to formulate a standard definition, Bruzek et al. (2016) identify and discuss several methods of quantifying ballast fouling. The Percent Passing Method attempts to quantify fouling material by equating percent fouling to percent passing of a certain sieve. There is no standard accepted sieve size, as some countries define fouling material as percent passing the No. 200 sieve while others use percent passing the 1-inch sieve.

The Fouling Index (FI) attempts to quantify fouling with the following equation:

$$FI = P_4 + P_{200}$$

"where P_4 is the percentage of particles passing the No. 4 sieve and P_{200} is the percent of particles passing the N. 200 sieve by weight" (Bruzek et al. 2016). This method gives more weight to the percent passing the No. 200 sieve because it is counted two times.

The Percent Void Contamination (PVC) method was developed to address issues with coal ash contamination. Coal ash is much lighter than soil and, therefore, yielded inaccurate

FIGURE 4 Moderate ballast fouling at a site in Texas – December 2022.

FIGURE 5 Severe ballast fouling at a site in Texas – December 2022.

FIGURE 6 No ballast fouling observed at a site in Texas – December 2022.

results when measuring the weight of retained particles. PVC utilizes the following equation:

$$PVC = \frac{V_2}{V_1} * 100\%$$

"where V_1 is the void volume between clean ballast particles (>9.5 mm) and V_2 is the total volume of fouling material (<9.5 mm) that fills V_1" (Bruzek et al. 2016).

Finally, Void Contamination Index (VCI) is a more complex variation of the PVC. VCI considers the void ratio, specific gravity and dry mass of both the fouling material and the clean ballast. VCI is calculated with the following equation:

$$VCI = \frac{(1 + e_f)}{e_b} * \frac{G_{sb}}{G_{sf}} * \frac{M_f}{M_b} * 100$$

"where e_b is the void ratio of clean ballast, e_f is the void ratio of the fouling material, G_{sb} is the specific gravity of clean ballast, G_{sf} is the specific gravity of fouling material, M_b is the dry mass of clean ballast, and M_f is the dry mass of fouling material" (Bruzek et al. 2016).

These methods all have advantages and disadvantages. One key advantage is that each of these methods quantifies the level of ballast fouling present, either by weight or volume. However, the primary disadvantage is that their applicability in the field is limited because each method requires ballast excavation and laboratory testing.

The requirement of laboratory analysis almost always deters rail companies from attempting to quantify ballast fouling when observed. Testing would require the rail line to be taken out of service for extended periods of time to allow for ballast to be excavated and analyzed. According to Steffer, ballast fouling is usually identified during a visual inspection. Determining when the section becomes overly fouled is difficult and poses a significant challenge. Replacing the ballast the moment fouling becomes noticeable is too costly; however, addressing the issue too late can pose significant safety issues. The photos on the opposite page show different degrees of ballast fouling.

The key to protecting the ballast from fouling is protecting the sub-ballast. When trains are in motion, a pumping phenomenon occurs, allowing fines and other deleterious materials to migrate up into the sub-ballast. This pumping effect is magnified in saturated subgrade conditions, increasing the risk of sub-ballast contamination. Once the sub-ballast is compromised, it essentially becomes the new subgrade. At that point, the overlying clean ballast is at significantly greater risk of becoming fouled.

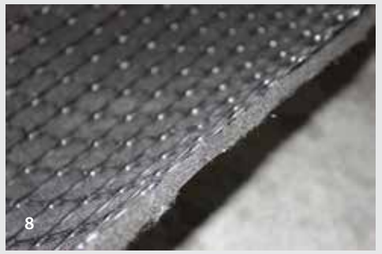


FIGURE 7 A top down view of BaseLok® BallastGuard™ showing the BL6 geogrid and fabric.

FIGURE 8 A cross-sectional view of BaseLok® BallastGuard™ showing the thickness of the proprietary blended fabric.

FIGURE 9 A cross-sectional view of BaseLok® BallastGuard™ showing the thickness of the proprietary blended fabric.

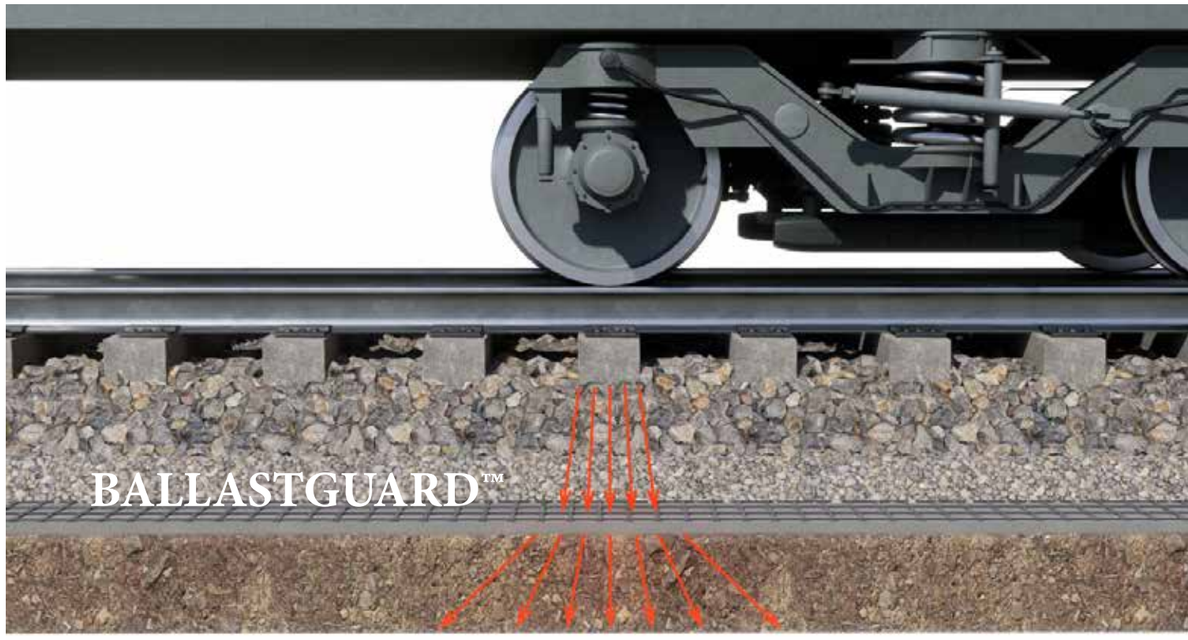


FIGURE 10 Initial installation of BaseLok® BallastGuard™ along a seawall at the Port of Texas City – May 2021. Photo courtesy of Karis Loughner

FIGURE 11 BaseLok® BallastGuard™ test section in service at the Port of Texas City – July 2022. Photo courtesy of David Bullock

FIGURE 12 BaseLok® BallastGuard™ test section in service at the Port of Texas City – December 2022.

Preventing ballast fouling is attractive to railroads, rail facilities, storage facilities, switchyards and other sites where rail is maintained. If ballast fouling can be eliminated or delayed and maintenance cycles extended, companies like Texas City Terminal Railway Company win by cutting costs, improving safety, and decreasing outages and downtime.

Addressing the ballast fouling issue

Texas City Terminal Railway Company is receptive to trying new technologies. In the spring of 2021, Industrial Fabrics, Inc. presented a solution that would significantly decrease the ballast fouling at the Port of Texas City. Industrial Fabrics, Inc. had developed a new product specifically designed to address this phenomenon. The product would later earn the name BaseLok® BallastGuard™.

Industrial Fabrics's geotextile partner is a leader in geotextile manufacturing in the United States. As such, they knew a traditional polypropylene or polyester nonwoven would not be sufficient to mitigate the effects of pumping caused by train movement. Additionally, they recognized a more robust product would be needed to reduce ballast fouling—a product that would prevent the migration of even the most persistent fines while still allowing the section to drain properly. After significant testing and design work, they created a heavyweight needlepunched nonwoven fabric comprised of a proprietary blend of polyester and polypropylene fibers for this application. Industrial Fabrics's contribution to the product came through the inclusion of a high-strength, high-stiffness biaxial geogrid and lamination service. They decided BaseLok BL6 was the most appropriate product to laminate to the geotextile due to its high level of performance. BaseLok BL6 is a high-strength, punched and drawn biaxial geogrid with a high aperture stability modulus. It is also one of the stiffest geogrids available on the market and is routinely recommended for sub-ballast reinforcement in rail designs completed by Industrial Fabrics's team of professional engineers.

Texas City Terminal Railway Company and the Port of Texas City decided to demo BaseLok BallastGuard on a problematic section of track located along a seawall within 150 feet of Galveston Bay. This section of track required routine maintenance approximately every 36 months due to significant ballast fouling. "Common practice for most railroads regarding the remediation of fouled ballast within existing track structure has been to repair or upgrade track side drainage, undercut and crib out fouled ballast, add clean aggregate and finally surface the area via on-track equipment" (Brooks and Steffer 2022). The fact that the BaseLok BallastGuard is 100% manufactured in the United States is important to Texas City Terminal Railway Company. Since Congress passed the Build America, Buy America Act in 2022, this is even more important. While there are other geosynthetics products marketed to address this application, none of them are manufactured in the United States. As previously mentioned, traditional nonwoven geotextiles are not specifically designed to address ballast fouling and are expected to fail prematurely.

The test section at the Port of Texas City has been in service since May 2021. As of December 2022, no ballast fouling has been observed. Steffer says, "We have been incredibly pleased with Industrial Fabrics's BallastGuard product. Areas where this product has been installed show no signs of fouled ballast nor any signs of track geometry deflection typically caused by underlying ground stabilization issues." The Port of Texas City plans to use this technology moving forward, as well.

FIGURE 13 BaseLok® BallastGuard™ test section in service at the Port of Texas City – December 2022.

Conclusion

The ballast fouling phenomenon is a difficult issue to address. Currently no standard exists by which to measure the severity of ballast fouling. Though several studies have attempted to create some metric for in situ evaluation of ballast material, all methods require invasive laboratory testing. The U.S. rail industry does not indicate that any ballast fouling standard will be adopted in the foreseeable future. As such, addressing ballast fouling is left to each individual railroad or site manager.

>> For more, search **ballast** at GeosyntheticsMagazine.com.

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United States Department of Transportation (USDOT), Federal Railroad Administration. 49 C.F.R. § 213.103 (2022).

CASE STUDY

Port Facility - SE Texas Rail Maintenance Test Section

Anti-Pumping Geocomposite to Eliminate Ballast Fouling

PROJECT TEAM

OWNER:
Non-Disclosed Port Authority
Houston,TX

ENGINEER:
NA

CONTRACTOR:
Non-Disclosed Contractor
Houston, TX

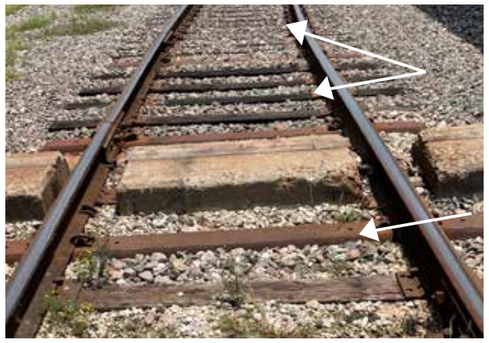
SUPPLIER:
Industrial Fabrics, Inc. (IFI)

TECHNICAL DESCRIPTION:

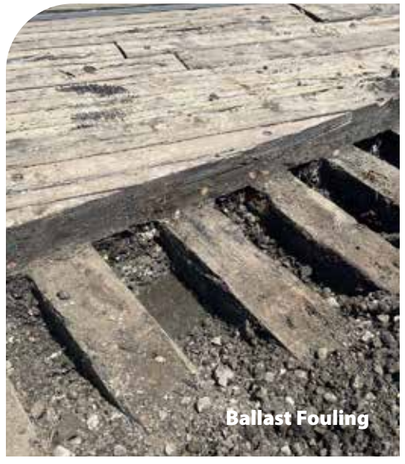
Product: **BASELOK®**
BallastGuard

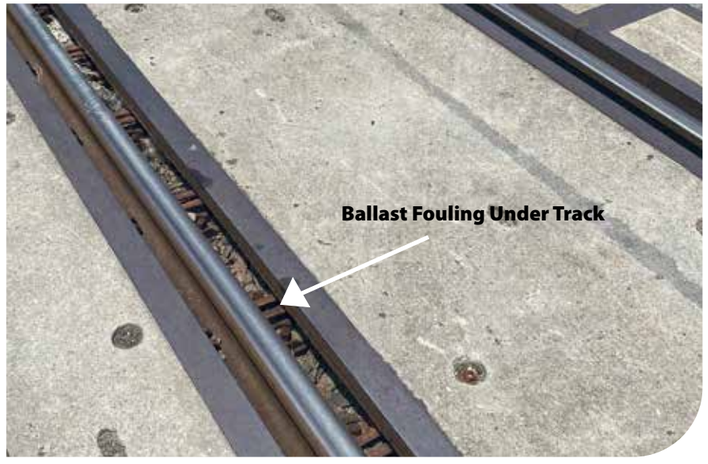
Square Feet: <10,000 SF


BaseLok® BallastGuard™ Installation


With Baselok® BallastGuard™

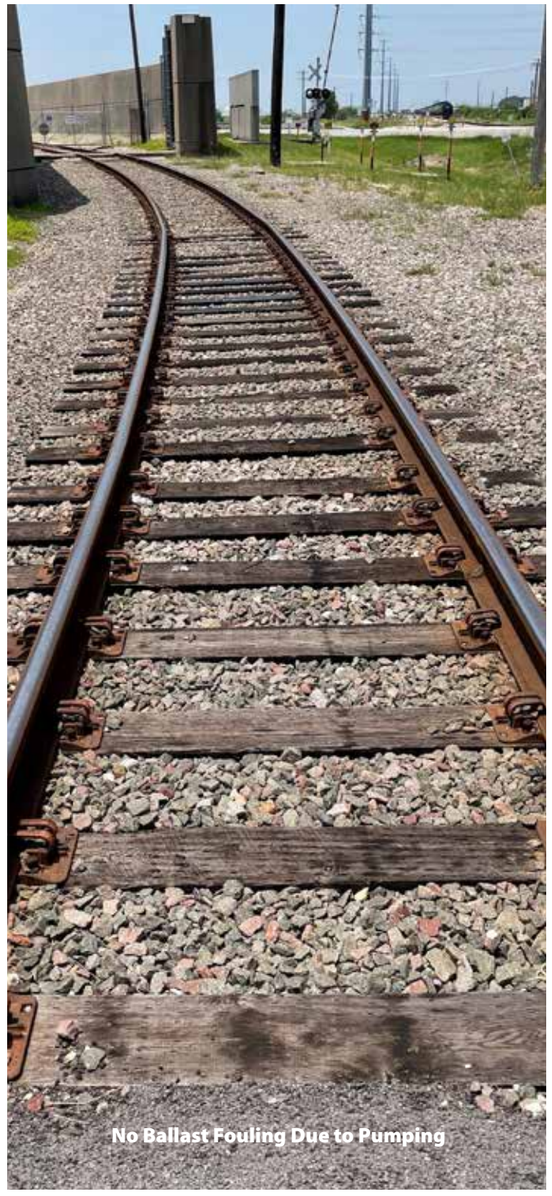
Without BaseLok® BallastGuard™


Ballast Fouling


Ballast Fouling Under Track

Port Facility - SE Texas Rail Maintenance Test Section

Anti-Pumping Geocomposite to Eliminate Ballast Fouling


No Ballast Fouling Due to Pumping

PROJECT DESCRIPTION:
A port facility with more than 10 miles of rail in Southeast Texas needed to address ballast that had been contaminated with fines from the subgrade.

PROBLEM:
Ballast fouling is an issue that is challenging for rail owners to deal with throughout the United States and the world. It is caused by pumping action created when railcars repeatedly pass over railways built over weak and saturated soils. When a site is located at a port facility, the groundwater almost always creates a challenge. The subgrade typically remains saturate and when the dynamic load of a train passes over these areas, water jets up (pumps) into the clean subballast and ballast. Once contaminated with fines from the subgrade, the subballast and ballast lose structural integrity which can potentially cause track systems to fail. As such, routine maintenance in these areas is required and often at much higher frequency.

SOLUTION:
A few years ago, IFI recognized the need for a domestically produced solution to this ongoing issue and decided to develop a product to address the need. Working with a premium geotextile manufacturer, we developed BaseLok® BallastGuard™. The key to a product that will perform successfully is the ability of the product to resist the pumping effect of the water, yet still drain and keep water from being trapped in the section. BaseLok® BallastGuard™ is a 240 mil (0.24in) thick geocomposite comprised of BaseLok® BL6 Geogrid and a needle punched, non-woven geotextile comprised of a proprietary blend of virgin polyester and polypropylene fibers specifically modified to address anti-pumping phenomena in rail applications. The BaseLok® BallastGuard™ not only prevents the pumping, but also repels water to help the system drain more efficiently. Additionally, the BaseLok® BL6 Geogrid interlocks with the overlying aggregate, reinforcing the subballast and enhancing the performance of the overall section.

RESULTS:
The port manager at this facility has been extremely impressed with the performance of the BaseLok® BallastGuard™. The test section has been in for 15 months, and no additional maintenance has been required. The section is still clean, and no ballast fouling has been observed. The port plans to incorporate BaseLok® BallastGuard™ when additional maintenance is completed in the future and on all future expansions.

BALLAST GUARD™
Ballast Preservation System

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